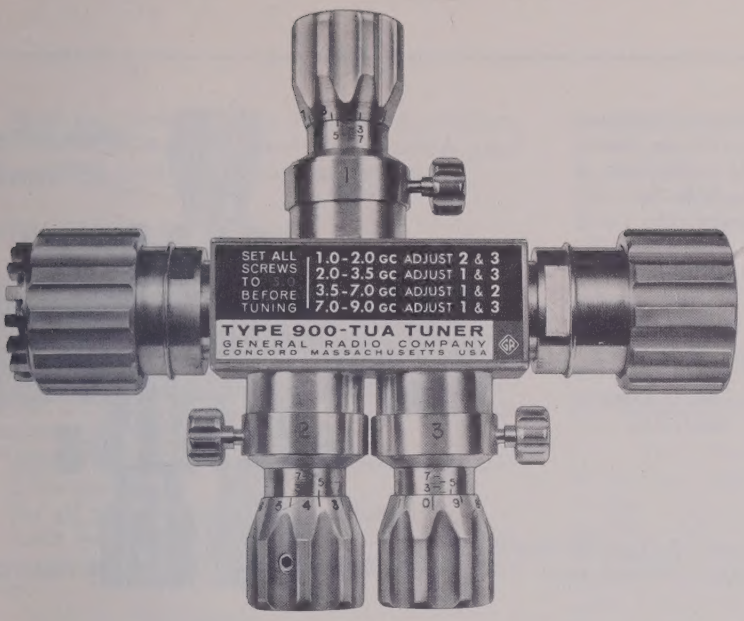
SET ALL SCREWS TO 5.0 BEFORE TUNING
1.0-2.0 Gc ADJUST 2 & 3
2.0-3.5 Gc ADJUST 1 & 3
3.5-7.0 Gc ADJUST 1 & 2
7.0-9.0 Gc ADJUST 1 & 3
TYPE 900-TUA TUNER
GENERAL RADIO COMPANY
CONCORD MASSACHUSETTS USA

TYPE 900-TUA TUNER

SPECIFICATIONS

Frequency Range: 1.0 to 9.0 Gc/s.
Characteristic Impedance: 50 ohms, nominal.
VSWR Matching Range: $1.00 + 0.012 \times f_{Gc/s}$ or $(1.2 \times f_{Gc/s})\%$, minimum.
VSWR Resettability: Within $1.0005 \times 0.0003 \times f_{Gc/s}$ or $(0.05 + 0.03 \times f_{Gc/s})\%$.
Connectors: Type 900-BT Precision Coaxial Connector at each end.
Residual VSWR: With all screws set to 5.0, less than 1.03, 1.0 to 5.0 Gc/s; 1.05, 5.0 to 7.0 Gc/s.
Insertion Loss: Less than 0.1 dB to 4.0 Gc/s; less than 0.3 dB to 9.0 Gc/s.
Number of Tuning Controls: Total of three; only two require adjustment at any given frequency.
Repeatability of Connection: 0.05%.
Electrical Length: 12.0 cm, nominal.
Dimensions: Length 4½ inches, height 3½ inches, depth 1 inch (115 by 88 by 25 mm), over-all.
Net Weight: 1 pound (0.5 kg).
***General Radio Experimenter* Reference:** Vol 39, No. 1, January 1965.

SECTION 1

INTRODUCTION

The Type 900-TUA Tuner is a compact screw-type tuner that is used to match out residual reflections of coaxial terminations, measuring instruments, connectors, and adaptors at frequencies between 1 and 9 Gc/s. This tuner comprises a section of 50-ohm coaxial transmission line with three adjustable tuning screws, distributed asymmetrically along the line. The screws are adjustable in both directions with respect to a "neutral" position, at which the reflection introduced by the tuner into a system is negligible.

The available tuning range of the Type 900-TUA Tuner is dependent on the phase of the reflection to be tuned out and on the frequency of operation. While reflections up to 2:1 can be tuned out under certain conditions, the maximum VSWR that can be tuned out under all conditions of mismatch phase and frequency is:

$$1.000 + 0.012 \times f_{Gc/s}.$$

Figure 1-1 shows the matching range.

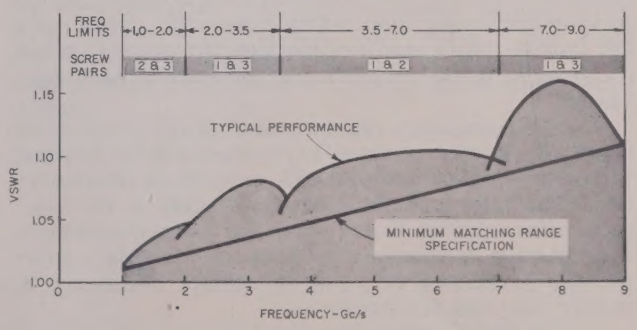

Figure 1-1. Matching range of Type 900-TUA Tuner.

The micrometer-type tuning screws have engraved scales and verniers, reading from 1.00 to 8.00, as shown in Figure 1-2. Screws to be adjusted as a function of frequency are tabulated on the nameplate. Note that only two screws are adjusted at any frequency; the third screw is locked in the neutral position, which is 5.00.

The locks, if partially made, permit smooth vernier adjustment of the tuning screws. If fully made, the locks provide long-term stability of adjustment and protection against accidental movement.

The tuner is fitted with Type 900-BT Precision Coaxial Connectors at both ends. Low-loss adaptors to popular 50-ohm connector series are available.

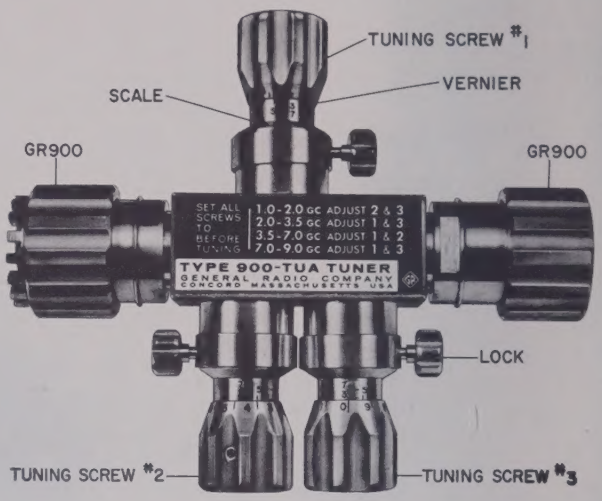

Figure 1-2. Type 900-TUA controls and indicators.

SECTION 2 OPERATING PROCEDURES

2.1 MATING OF GR900 CONNECTORS.

The GR900 Precision Coaxial Connectors, with which the tuner is fitted at both ports, are sexless and will mate with any other GR900 connector. Since only one locking nut is used per junction, provision is made for storage of the unused nut at the rear of each connector.

The connectors can be joined in any of 16 axial positions and the electrical performance of the junction will always repeat within 0.05%, regardless of orientation. The reference plane occurs exactly at the contact surfaces of the joined inner and outer conductors. The junction formed by the compact, one-piece connectors presents a very low dc contact resistance to ensure low-loss performance.

The tight mesh of the stainless steel centering-gear rings, augmented by the shielding of the chrome-plated coupling nut, holds rf leakage to 130 dB below signal level and makes for a firm, positive junction.

The mating procedure is as follows (see Figure 2-1):

a. To store the locking nut, slide it back until the threads engage. Then thread it back off the centering gear ring and slide it to the ridge at the rear of the coupling nut.

b. Move the locking nut of the other connector back slightly. Align the connectors axially and engage the teeth of the centering gear rings in any convenient orientation.

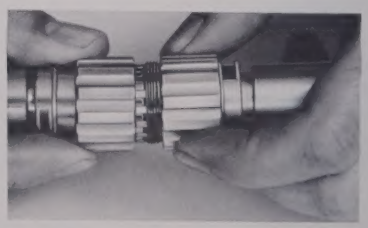

Figure 2-1. Mating of Type 900-BT connectors.

c. Hold the connectors in the joined position, thread the active locking nut over the centering gear ring of the mating connector, and hand tighten.

2.2 GENERAL TUNING PROCEDURE.

The tuning procedure is as follows:

a. By means of the Type 900-BT connectors, connect the Type 900-TUA Tuner into the system in which matching is desired. While axial orientation relative to the system is not critical, the tuner should be positioned so that all three scales can be read and all three tuning screws adjusted conveniently.

b. Adjust the tuning-screw locks so that an easy but firm drive results.

c. Set all three tuning screws to 5.00.

d. Lock the tuning screw that is to remain stationary for the operating frequency (as indicated on the nameplate).

CAUTION

Do not rotate tuning screws more than two turns beyond 1.0. There is no stop.

e. Alternately adjust the remaining two tuning screws for minimum reflection (minimum VSWR), until the required match is obtained.

For example, if the frequency is 4.2 Gc/s, set all tuning screws to 5.00 and lock tuning-screw 3. Adjust tuning-screw 1 for minimum reflection; adjust tuning-screw 2 for minimum reflection. Readjust tuning-screw 1 for minimum reflection; continue alternately readjusting tuning screws 1 and 2 for minimum reflection.

2.3 TUNING OF MISMATCH OUTSIDE SPECIFIED RANGE.

If the mismatch to be tuned out is outside the specified range of the tuner, it may still be possible to obtain a match with the following procedures:

a. Perform the procedure of paragraph 2.2.

b. If the degree of match achieved is not sufficient, unlock the third tuning screw and adjust it for best match.

c. Alternately adjust the original two tuning screws for minimum reflection.

d. If the degree of match still is not sufficient, set all the tuning screws back to 5.00 and insert a length of transmission line (see paragraph 4.1.4), that is approximately an odd multiple of a quarter wavelength at the operating frequency, between the tuner and the source of the largest reflection to be matched.

e. Repeat the procedure of paragraph 2.2.

f. If the degree of match achieved is not sufficient, repeat b and c above.

g. If the degree of match achieved is still not sufficient, the reflection to be matched is completely outside the range and a tuner with more range, or several Type 900-TUA tuners in series, should be used.

2.4 OPERATION 7-9 Gc/s.

The residual VSWR introduced by the Type 900-TUA in the range 7-9 Gc/s, with all tuning screws set to 5.0, is greater than 1.05. This residual can be reduced to less than 1.05 if screw #1 is set to 4.5. While the tuning procedures of paragraphs 2.2 and 2.3 are directly applicable for the 7- to 9- Gc/s range, faster convergence on match can usually be achieved if screw #1 is set at 4.5 initially. (Screws 2 and 3 should still be set to 5.0 to start.)

2.5 EFFECT OF MEASURING INSTRUMENT.

The ease of adjustment of the tuner, and the degree of match that can be achieved under given conditions of frequency and mismatch, are functions of the measuring instrument in use.

If a measurement of reflection coefficient is employed, with a measuring instrument such as a Type 1602-B UHF Admittance Meter, a hybrid, or a directional coupler, successive adjustments for minimum indication lead rapidly to the match condition. The match that can be achieved depends only upon the sensitivity and noise level of the system.

If a measurement of standing-wave ratio is employed, with a measuring instrument such as a slotted line, the procedure is more complex. The probe must be swept back and forth over a half-wavelength section of the slotted line while tuning, in order to obtain the correct adjustment for minimum standing-wave ratio. The degree of match that can be achieved when a slotted line is the measuring instrument depends directly on the resolution (or expansion) available with the standing-wave indicator used. The sizeable expansion offered by the supressed-zero chart scale of the Type 1640-A Slotted Line Recorder System furnishes extra resolution and will speed up and simplify the tuning procedure.

SECTION 3

PRINCIPLES OF OPERATION

3.1 DESCRIPTION.

The Type 900-TUA Tuner is actually three tuners in one. The individual tuners, in the primary mode, cover the frequency bands of 1-2 Gc/s, 1.8-3.6 Gc/s and 3.5-7.0 Gc/s, respectively. The 7-9 Gc/s range is covered by a second mode of the 1.8-3.6 Gc/s tuner. The reason that three tuners, to cover different frequency bands, can be combined in this way is that each individual tuning element in its "neutral" position introduces only small residual reflections over the entire frequency range of the device.

The individual tuners comprise a length of 50-ohm transmission line joining two tuning elements, each element pair spaced an eight-wavelength apart at the center frequency of the band of operation. At this frequency, adjustment of the tuning screws introduces orthogonal movements on the impedance plane. Over the two-to-one frequency band used, the electrical angle between the directions of movement varies from 60° to 120°.

The tuning screws introduce capacitive effects only. Therefore, by themselves, they cover an average of only one quadrant of the impedance plane. This coverage is extended to all four quadrants by introduction of an inductance in the plane of each tuning screw. This means that, with a tuning screw all the way out of the line, a net inductance is achieved. As the tuning screw is turned in, the neutral (zero-effect) position is reached. As the tuning screw is turned in farther, a net capacitance results.

Various combinations of the three tuning screws used provide three spacings; hence, the three frequency bands. An important working feature is that one starts tuning from the neutral position, at which point the tuner itself introduces only a small residual error. From this point, alternate adjustments of the two specified tuning screws always converge to match. There are no false nulls or sliding nulls.

3.2 ZERO POSITION.

Each tuning screw can be adjusted individually to introduce a very small reflection into a 50-ohm transmission line over a broad frequency range. The tuning range is then plus and minus relative to this position (5.00 on the scales). When all three screws are set to 5.00 the tuner introduces less than a 3% error into a matched 50-ohm system, up to a frequency of 5 Gc/s. Above 5 Gc/s, the error increases because of the increasing distribution of the reactances involved and because of interactions between tuning screws. Between 7 and 9 Gc/s the residual error is minimized with tuning screw number 1 set at 4.50.

3.3 A TUNING SECTION.

The combination of two screws and the section of transmission line between them comprises a tuning section capable of functioning in two modes. In the primary mode, the two screws of a tuning section are in phase quadrature (90° apart) at the center frequency of the range of operation of that section. The tuning range at the center frequency, therefore, lies approximately within a "square" about the nominal impedance, as illustrated in Figure 3-1 on an expanded Smith chart. The numbers at the corners of the squares are the tuning-screw positions. At frequencies above and below the center frequency, the square becomes a diamond. The corner at (7, 7), where both tuning screws are introducing maximum effect, gets accentuated or rounded off at some of the higher frequencies because of interaction between tuning screws.

For frequency bands 1.0-2.0 Gc/s, 2.0-3.5 Gc/s, and 3.5-7.0 Gc/s the three tuning sections are comprised of tuning screws 2 and 3, 1 and 3, and 1 and 2, respectively. Tuning screws 1 and 3 are used in a secondary mode to cover the frequency range 7.0-9.0 Gc/s. In this mode the tuning screws are 270° apart; however, since the tuning screws are adjusted plus and minus with respect to the neutral position, the result is the same as in the primary mode, except for narrower bandwidth.

3.4 CONVERGENCE.

If the procedure of paragraph 2.2 is followed in adjustment for a match, the tuning process is always convergent. That is, if all tuning screws are set initially to 5.00 and the mismatch to be adjusted lies within the specified tuning range, successive adjustments for minimum reflection (or VSWR) always converge on the optimum match. There is no ambiguity in achievement of match, a fact that is particularly important when only the magnitude of the reflection coefficient, or the standing-wave pattern, can be detected.

3.5 FREQUENCY DEPENDENCE.

Owing to the nature of the tuning arrangement, this device is not highly frequency-sensitive. Generally, small variations in source frequency do not substantially alter the degree of match. Of course, this is a rel-

ative situation. The match is more sensitive to frequency change when the tuner and the reflection being matched are far apart, than when they are close together; it is even more sensitive when the reflection being matched is large. Yet, when the reflection being matched is very small, the reflection introduced by the tuner itself remains negligible over a very wide frequency range. For example, when the tuner is terminated in a Type 900-W50 50-ohm standard termination and the tuning screws are set to 5.00, the input impedance of the tuner is 50 ohms, within 2 to 3%, from dc to 5 Gc/s.

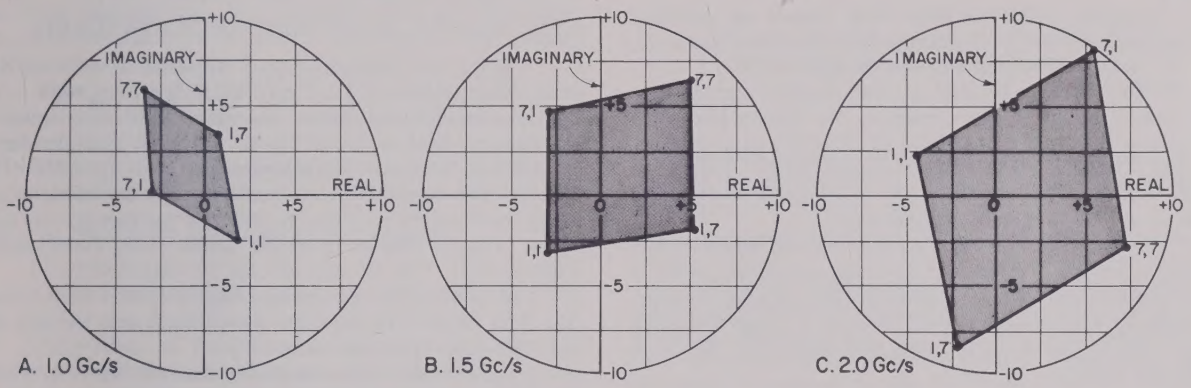

Figure 3-1. Expanded Smith chart plots of typical matching-range performance of the Type 900-TUA Tuner between 1 and 2Gc/s.

NOTES

1. Numbers at corners are settings of screws 2 and 3, respectively.
2. Axes are in percent deviation from match.
3. Tuning screw 1 is set at 5.00.
4. 10% match is VSWR of 1.100.

SECTION **4**

APPLICATIONS

4.1 GENERAL.

4.1.1 MATCHING TO A STANDARD OF IMPEDANCE.

The Type 900-TUA Tuner can be used to match out reflections in a wide variety of applications. It is particularly suitable for the reduction of residual reflections introduced by rf terminations, connectors, adaptors between line sizes, and measuring instruments (such as slotted lines, rf bridges, and directional couplers).

Residual reflections in a device must always be considered with respect to some standard of impedance. The standard may be part of a measuring instrument, or it may be a termination, or a section of precision air line. The standard may or may not be equipped with GR900 connectors. Whatever the nature of the standard of impedance employed, it is often desirable to match the impedance of other devices to it. This can be accomplished in several ways, depending on the nature of the standard available and the nature of the device to be matched to it. Representative procedures for use of the Type 900-TUA Tuner in such applications are described below.

4.1.2 INSTRUMENT AS AN IMPEDANCE STANDARD.

When a coaxial measuring instrument (e.g. Type 900-LB Precision Slotted Line, Type 1602-B UHF Admittance Meter, directional coupler, hybrid, etc) is taken as a standard of impedance, a termination that matches the standard can be achieved in the following manner:

a. Make a composite termination (which will be the final matched termination) by connection of the Type 900-TUA Tuner to a nominal 50-ohm termination, such as the Type 900-W50 (paragraph 4.3.4).

b. Attach this composite termination directly to the standard measuring instrument, as shown in Figure 4-1.

c. Adjust the Type 900-TUA Tuner as outlined in paragraph 2.2 (or as in paragraph 2.3, if necessary).

d. Lock all tuning screws in place.

If the match indicated by the measuring instrument is as good as it can resolve, the composite termination is as good a standard of impedance as can be achieved with the measuring instrument used. The composite termination can then be used as a secondary standard at the operating frequency.

If the standard measuring instrument is not equipped with a GR900 connector but, for example, with a type-N jack connector, a standard type-N plug termination can be achieved by insertion of a Type 900-QNP Adaptor ahead of the composite termination. Refer to paragraph 4.3.5.

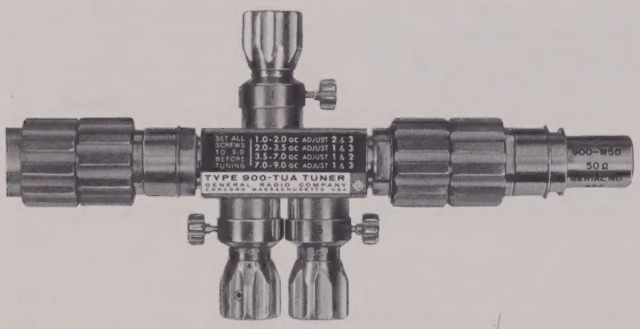

Figure 4-1. Composite termination, consisting of Type 900-TUA Tuner with Type 900-W50 Termination, attached to an instrument.

4.1.3 A TERMINATION AS AN IMPEDANCE STANDARD.

When a termination such as the Type 900-W50 (paragraph 4.3.4), is taken as a standard of impedance, a measuring instrument can be matched by the tuner so that it is free of residual reflections. The procedure for tuning closely resembles that of paragraph 4.1.2 and is as follows:

a. Make a composite measuring instrument by connection of a Type 900-TUA Tuner to the output (or unknown) terminal of the measuring instrument.

b. Attach the standard termination directly to the composite measuring instrument. (This is the same configuration as shown in Figure 4-1 except that the tuner is here considered part of the measuring instrument, rather than part of the termination.)

c. Adjust the Type 900-TUA Tuner as outlined in paragraph 2.2 (or as in paragraph 2.3, if necessary).

d. Lock all tuning screws in place.

If the indicated match is as good as can be resolved by the measuring instrument, the measuring instrument is as good a standard of impedance as its limit of resolution, and can be used as a secondary standard.

If a standard termination is available in a line size other than GR900, measuring instruments in that line size can be matched to the standard termination with adaptors from the GR900 terminals of the tuner to the line sizes involved (paragraph 4.3.5).

4.1.4 AIR LINE AS AN IMPEDANCE STANDARD.

When the characteristic impedance of a section of air line, such as the Type 900-LZ (paragraph 4.3.2) is taken as the impedance standard, both a measuring instrument and a termination can be independently matched to the standard impedance. Two Type 900-TUA Tuners are required, one to make a composite measuring instrument and one to make a composite termination. Follow the procedure below with reference to Figure 4-2:

a. Select an operating frequency at which the air line will be an odd quarter wavelength and set the signal source accurately to it.

b. Connect the composite measuring instrument and the composite termination directly together.

c. Set all tuning screws on both Type 900-TUA Tuners to 5.00.

d. Adjust tuner B for match per paragraph 2.2.

e. Record the positions of the tuning screws of tuner A.

NOTE

Screws will be at 5.00 for the first time through the tuning procedure only.

f. Insert the air-line standard between the composite measuring instrument and the composite termination.

g. Adjust tuner A for match, as in paragraph 2.2.

h. Record the new positions of the tuning screws of tuner A.

i. Set the tuning screws of tuner A individually to the average of the readings recorded in steps e and h above.

j. Readjust tuner B for match.

k. Remove the air line and reconnect the system as in step b.

l. Measure the residual error. At this point, the error is twice that of the composite measuring instrument (or of the composite termination). If the error is too large, repeat steps d through k until the desired match is obtained.

m. When the desired match is obtained, lock all tuning screws on both tuners.

Figure 4-2. Set-up for matching composite measuring instruments and composite terminations to the impedance of a standard section of air line.

The composite measuring instrument and the composite termination are both individually matched to the characteristic impedance of the standard air line and can be used independently as secondary standards at the frequency in question.

The procedure outlined above is applicable in any coaxial line size, provided that a standard air line in the line size, and appropriate Type 900-Q precision adaptors, are available to permit connection of the tuners (refer to paragraph 4.3.5).

This procedure is directly convergent to match, if the air line used is an odd multiple of a quarter wavelength of the frequency used. If the air line is not an odd multiple of quarter wavelength, repetition of steps d to l will afford convergence to match at a rate of

(100 cos $360° \frac{\ell}{\lambda}$ %) per repetition, where:

ℓ is the length of the air line in cm

λ is the wavelength of the operating frequency in cm.

Operation at frequencies at which the air-line length deviates by more than an eighth wavelength from an odd multiple of a quarter wavelength is not recommended, since the convergence rate is relatively slow. Refer to paragraph 4.3.3 for a description of precision air line kits available from General Radio.

4.2 SUBSTITUTION TECHNIQUES.

4.2.1 GENERAL.

Substitution techniques for measurement of low residual reflections, such as described by Sanderson [1,2], can be accomplished without the use of a tuner. However, the results of the two measurements made have to be subtracted vectorially.

While this is readily accomplished with the Type 1640-A Slotted Line Recorder System, it is often convenient, when many measurements are to be made, to make one of the vectors zero with the tuner, so that the other vector alone provides the answer. Also, if only the magnitude of the answer is required, phase sensitive measuring equipment is not required. This means that it is not necessary to plot measurements on a Smith chart, lay out constructions, and perform vectorial subtractions. The answer is obtained directly from magnitude considerations alone.

4.2.2 HALF-WAVE SUBSTITUTION.

If a uniform section of air line that is a multiple of a half wavelength long at the operating frequency is inserted between a measuring instrument and a termination, the resultant indicated reflection coefficient is identical to that measured with the termination connected directly to the measuring instrument. Such an air line is a 1:1 transformer and is a convenient mount to perform comparison measurements on coaxial connectors.

If a tuner is used without the air line (as shown in Figure 4-3) and is adjusted so that a match is indicated, then, if the air line is inserted a match should still be indicated. If there are any discontinuities present in the air line, such as in the connectors, a match will not be indicated in the second case. The degree of mismatch is a direct measure of the discontinuities present in the connectors, relative to the characteristic impedance of the air line [3].

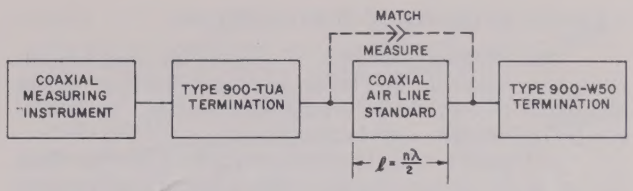

Figure 4-3. Half-wavelength substitution measurement technique in a matched system.

4.2.3 SUBSTITUTION MEASUREMENTS OF TWO-PORTS.

If an air line of well-defined characteristic impedance is available that is the same electrical length, ℓ, as an unknown two-port network to be measured, the following procedures can be used to determine the reflection introduced by the unknown network, independent of any reflections in the measuring instrument or the termination.

a. Connect the measuring instrument, the air line, the tuner and the termination, as shown in Figure 4-4. (The tuner should be attached to the measuring instrument, if the instrument's residual error is significantly greater than that of the termination.) Here, the termination error is assumed larger than the measuring-instrument error and the tuner is attached to the termination.

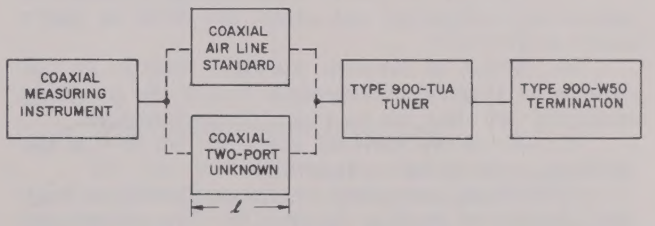

Figure 4-4. Substitution measurement technique for a two-port unknown.

b. Adjust the tuner so that a match is indicated.

c. Remove the air-line standard and replace it by the unknown. (The air-line standard and the unknown network must have the same electrical length within an even multiple of a half wavelength at the operating frequency.)

d. The indicated match is then that of the unknown network relative to the characteristic impedance of the air-line standard.

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[1] A. E. Sanderson, "A New High-Precision Method for the Measurement of the VSWR of Coaxial Connectors," IRE Transactions on Microwave Theory and Techniques, Vol MTT-9, No. 6, November 1961, pp 524-528.

[2] A. E. Sanderson, "An Accurate Substitution Method of Measuring the VSWR of Coaxial Connectors," The Microwave Journal, Vol 5, No. 1, January 1962, pp 69-73.

[3] "Operating Instructions, Type 900-LB Precision Slotted Line," General Radio Company, West Concord, Massachusetts, 1964.

4.2.4 QUARTER-WAVE SUBSTITUTION.

The residual error of a measuring instrument, or of a termination, can be measured directly as shown in Figure 4-5, by the following procedures. To measure an instrument residual error:

a. Connect a termination, through a Type 900-TUA Tuner, to the measuring instrument and adjust the tuner so that a match is indicated.

b. Insert an air-line standard that is an odd multiple of a quarter-wavelength long at the operating frequency between the measuring instrument and the tuner.

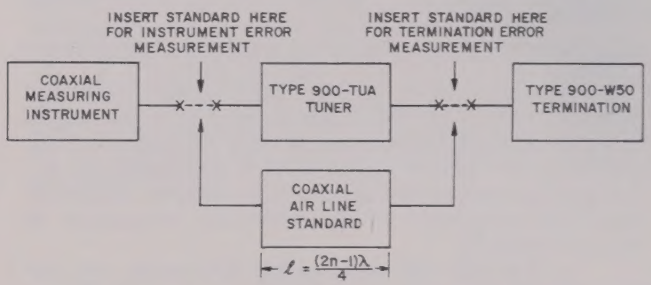

INSERT STANDARD HERE FOR INSTRUMENT ERROR MEASUREMENT
INSERT STANDARD HERE FOR TERMINATION ERROR MEASUREMENT
COAXIAL MEASURING INSTRUMENT
TYPE 900-TUA TUNER
TYPE 900-W50 TERMINATION
COAXIAL AIR LINE STANDARD
$\ell = \frac{(2n-1)\lambda}{4}$

Figure 4-5. Odd quarter-wavelength substitution measurement technique to separate instrument from termination error.

c. Divide the indicated mismatch by two to find the residual error of the measuring instrument.

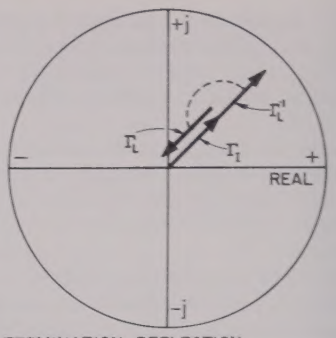
To measure the residual error of the termination:

a′. Connect the termination through a tuner to a measuring instrument and adjust the tuner so that a match is indicated.

b′. Insert an air-line standard that is an odd multiple of a quarter-wavelength long at the operating frequency between the tuner and the termination.

c′. Divide the residual error by two to find the residual error of the termination.

This latter procedure is further illustrated in an expanded Smith chart in Figure 4-6. The adjustment of the tuner makes the reflection, Γ_I, of the composite measuring instrument (measuring instrument plus tuner) cancel the reflection of the termination, Γ_L, as shown. With the air-line inserted, since it is an odd quarter-wavelength long, the termination reflection is rotated 180° on the Smith chart (90 electrical degrees), relative to the composite measuring instrument reflection, to Γ_L'. Since the composite measuring instrument reflection and the termination reflection were initially equal in magnitude, the termination reflection is just one-half the magnitude of the indicated reflection when the air-line is inserted.



Γ_L = TERMINATION REFLECTION
Γ_I = COMPOSITE MEASURING INSTRUMENT REFLECTION
Γ_L' = Γ_L ROTATED 180° BY AIRLINE

Figure 4-6. Operation of tuner plus air line on Γ measurement.

If the measuring instrument has negligible error and an unknown network is connected as part of the measuring instrument, the first procedure above yields a measure of the unknown network, independent of the termination residual. Similarly, if the termination has negligible error and an unknown network is connected as part of the termination, the second procedure above yields a measure of the unknown network, independent of the measuring-instrument residual.

4.2.5 INSERTION-LOSS MEASUREMENTS.

The Type 900-TUA Tuner finds some use in insertion-loss measurements, where it can be used to match out residual reflections introduced by attenuator pads, ferrite isolators, and other impedance-matching networks. The range of tuning is somewhat limited for this type of application, but stable and repeatable connections can be made at the tuner ports.

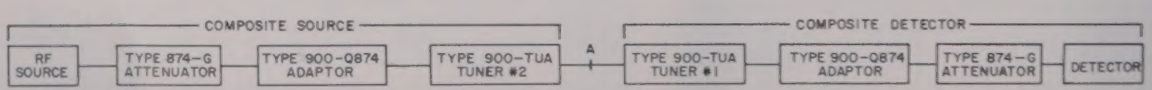
In the arrangement shown in Figure 4-7, tuner 1 can be adjusted so that the composite detector is a matched detector and tuner 2 can be adjusted so that the composite source is a matched source.

Match the composite detector by observation of the impedance of the detector from point A (with an external impedance measuring instrument). Adjust tuner 1 as in paragraphs 2.2 and 2.3.

The composite source can be matched in one of two ways. First, assume that the isolation of the pad is large enough to permit the effect of the source impedance (reflected through the pad) to be neglected. Measure impedance at A, looking back toward the source, with a nominally matched load in place of the r-f source. Adjust tuner 2 as in paragraphs 2.2 and 2.3.

Or, assume that the source isolation is insufficient. Connect the matched composite detector directly

Figure 4-7. Equipment setup for insertion loss measurements.



to the composite source, as in Figure 4-7. Insert an air-line standard at A (an odd multiple of a quarter-wavelength long) and adjust tuner 2 until the detector indication is the same with and without the air line. Now, the source is matched to the detector, which had previously been matched to 50 ohms, and the insertion loss of a device inserted at A can be measured directly.

If the detector, or the source, cannot be matched with the above techniques, then the tuner matching range may not be sufficient. Other tuners of greater range, such as a Type 874-D20L Adjustable Stub (installed in a Type 874-TL Tee), or a stub plus a line stretcher, could be interjected between the pad and the adaptor, in either place, to bring the mismatch within the range of the Type 900-TUA Tuner.

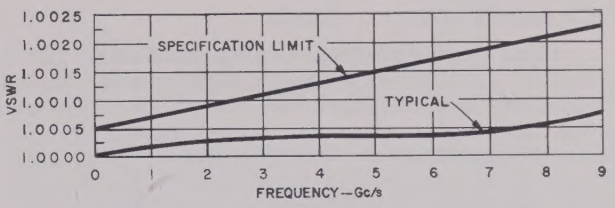


Figure 4-8. VSWR performance of Type 900-LZ Reference Air Lines.

4.3 PRECISION COAXIAL ACCESSORIES.

4.3.1 GENERAL.

In coaxial transmission-line systems, a section of uniform transmission line is ordinarily used as the impedance standard, since the absolute accuracy of the line's characteristic impedance is determined directly by the conductor diameters. Among GR900 coaxial elements are the Type 900-LZ Reference Air Lines, which provide the ultimate in impedance standards.

Other accessories are the Type 900-W50 50-Ohm Standard Termination and adaptors to commonly used 50-ohm connector series.

4.3.2 REFERENCE AIR LINES.

The Type 900-LZ Reference Air Lines are recommended for use in the foregoing applications with the Type 900-TUA Tuner. The function of the air line is to provide an absolute impedance standard based on the close tolerance diameters of the coaxial conductors. In the Type 900-LZ series, the characteristic impedance of the air line, at frequencies where skin depth is negligible, is 50 ±0.025 ohms, or ±0.05%.

The lines are available in 5, 6, 7.5, 10, 15 and 30-cm lengths. They comprise a uniform cross-section from one connection point to the other, with no beads or slots to introduce reflections. The inner conductor is supported by spring-loaded insert tips at each end, which engage the center-conductor contacts of the mating Type 900-BT connectors. Except for the GR900 coupling hardware, which threads directly on the outer conductor, there are no "connector" parts, as such, on these air lines, hence no discontinuities. Residual VSWR performance of the air lines is shown in Figure 4-8.

4.3.3 AIR LINE KITS.

Should an air line standard be required, of a length other than those in the Type 900-LZ Reference Air Line series, precision parts are available from General Radio to construct lines of equivalent performance. Precision air lines of up to 45-cm length can be fabricated from the parts listed in Table 4-1.

Complete machining and other detailed fabrication instruction are supplied with the kits.

TABLE 4-1

GR900 AIR LINE STANDARD KITS

PART	*NAME*	*PART NUMBER*
Outer Conductor	Precision Tube	0900-9509
Inner Conductor	Precision Rod	0900-9508
Coupling Hardware and Insert Tip	Type 900-AP connector kit (2 required)	0900-9406

4.3.4 TYPE 900-W50 TERMINATION.

The Type 900-W50 50-Ohm Standard Termination is a broadband device with extremely low VSWR useful with the Type 900-TUA Tuner across the latter's full frequency range. It comprises an accurately derived, continuous transition and precision cylindrical resistor. The connector is the GR900. Typical VSWR characteristics are given in Figure 4-9. The change in resistance and VSWR vs heating due to incident power is negligible up to 1-watt incident power.

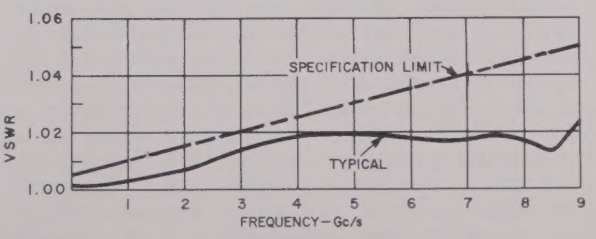


Figure 4-9. VSWR performance of the Type 900-W50 Termination.

4.3.5 ADAPTORS.

Low-loss adaptors to the hermaphrodite GR874 connector and to other leading 50-ohm connector series (in plug and jack versions) are available to permit use of the tuner with instruments, standards, and terminations in those line sizes without serious degradation of tuner performance. The adaptors available and pertinent information about them appear in Table 4-2.

TABLE 4-2
ADAPTORS AVAILABLE FROM GR900 TO COMMON COAXIAL CONNECTOR TYPES

To Type	*Type*	*Contains GR900 and. .*	*Connects GR900 to. .*
BNC	900-QBJ 900-QBP	BNC Jack BNC Plug	BNC Plug BNC Jack
C	900-QCJ 900-QCP	C Jack C Plug	C Plug C Jack
GR874	900-Q874	GR874	GR874
N	900-QNJ 900-QNP	N Jack N Plug	N Plug N Jack
TNC	900-QTNJ 0900-QTNP	TNC Jack TNC Plug	TNC Plug TNC Jack

4.4 PRECISION COAXIAL EQUIPMENT.

4.4.1 TYPE 1640-A SLOTTED LINE RECORDER SYSTEM.

This complete system automatically and accurately plots VSWR's from 1.001 to 1.20 as well as position of minima and reference plane. It consists of a Type 900-LB Slotted Line linked to a Type 1521-SL Slotted Line Recorder, which drives the probe carriage of the line and synchronously and faithfully provides a permanent plot of the detector output.

4.4.2 TYPE 900-LB PRECISION SLOTTED LINE.

This 50-cm, coaxial slotted line, terminated in a Type 900-BT connector, has the same VSWR characteristics as the connector from 300 Mc/s to 9 Gc/s. It has a characteristic impedance of 50 ohms ±0.1%, scale accuracy of ±(0.1mm +0.05%), and a constancy of probe pick-up of ±0.5%. Residual VSWR is less than $1.001 + 0.001 \times f_{Gc/s}$. Supplied complete with vernier-drive carriage, adjustable probe, tuning stub, and crystal detector.

SECTION 5

SERVICE AND MAINTENANCE

5.1 WARRANTY.

General Radio warrants that each new instrument sold direct is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or part that is found within the two-year period not to meet these standards after examination by our factory, district office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes, semiconductors or batteries that have given normal service.

5.2 SERVICE.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department, giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or

nearest Sales Engineering Office, requesting a "Returned Material Tag." Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.3 EXTERIOR INSPECTION AND CLEANING.

Occasionally inspect the GR900 connectors at both ports of the tuner for accumulations of dust or grime which could degrade performance. Use any commercial solvent to degrease the butt surfaces of inner and outer conductors.

NOTE

Retain the plastic caps supplied with the tuner to protect the connectors when the device is not in use.

If satisfactory performance is not obtained, inspect the connectors for nicks or protrusions (however minor) on the reference-plane surfaces of the outer conductors, and for damage to the inner conductor. The spring contact should be inspected to ascertain that the segments have not been accidentally bent or twisted.

Replacement parts for the connectors are available should the originals become damaged or worn. However, if replacement is required, return the tuner to General Radio for repair and recalibration.

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*Repair services are available at these offices.

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